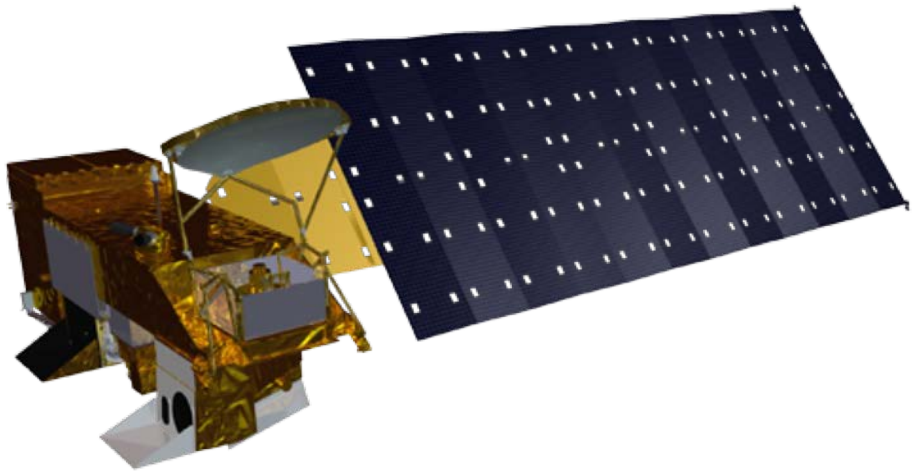


# Aqua Mission Update

Claire L. Parkinson
Aqua Project Scientist
NASA Goddard Space Flight Center

Presented at the NASA Sounder Science Team Meeting,
Crowne Plaza Hotel, Greenbelt, Maryland, October 1, 2018

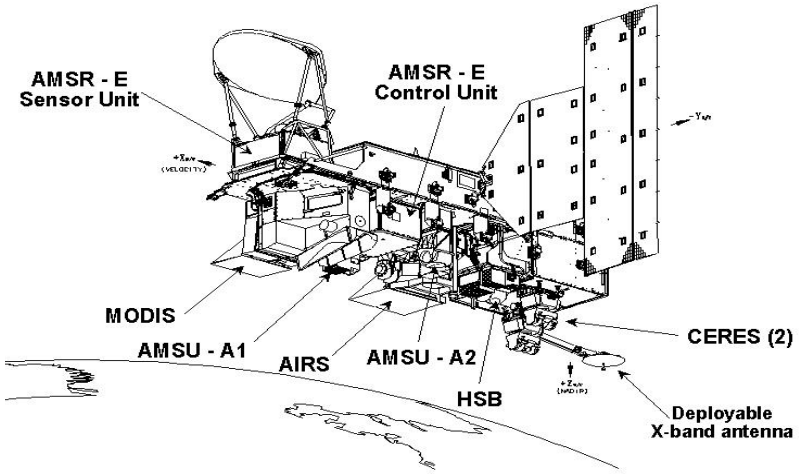
# Aqua Overview

- Launched May 4, 2002.
- Altitude of 705 km; 1:36 a.m. and 1:36 p.m. equatorial crossing times.
- First satellite in the A-Train.
- Six Earth-observing instruments.
- Data used in thousands of scientific publications and wide-ranging practical applications.
- Six-year design life.
- Likely can continue operating in the A-Train to 2022.


(photo by Bill Ingalls)

Aqua launch May 4, 2002

# Aqua's Instrument Suite

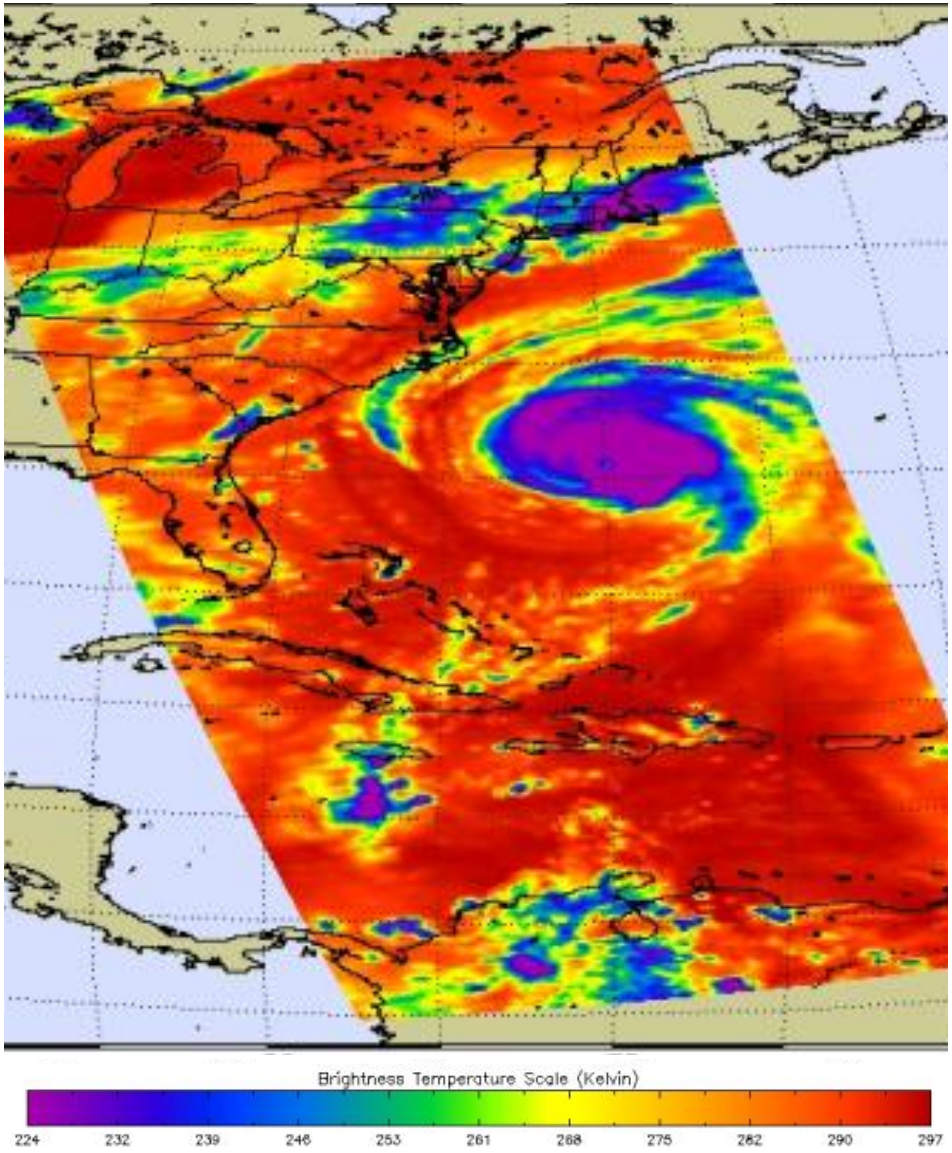



- Operating Instruments
  - AIRS: Atmospheric Infrared Sounder.
  - AMSU: Advanced Microwave Sounding Unit.
  - CERES: Clouds and the Earth's Radiant Energy System (2 copies).
  - MODIS: Moderate Resolution Imaging Spectroradiometer.
- Non-Operating Instruments
  - HSB: Humidity Sounder for Brazil (provided by Brazil; non-operational since February 2003).
  - AMSR-E: Advanced Microwave Scanning Radiometer for the Earth Observing System (provided by Japan; excellent record until October 2011; some operations since then; turned off on March 2, 2016).

Aqua pre-launch (courtesy of Northrop Grumman)

# AIRS/AMSU

- AIRS – Excellent health
  - Voltages, currents, temperatures all look good.
  - Only ~ 200 of 2378 infrared channels are degraded (primarily due to radiation).
- AMSU – Fair health
  - Voltages, currents, temperatures all look good.
  - 8 of 15 channels continue to perform well.
    - Channels 1, 2, 4, 5, and 7 were all degraded and removed from Level 2 processing before 2018.
    - Channel 14 underwent an unexpected shift (anomaly) on 6/21/18; no recovery attempts are planned.
    - Channel 6 is slowly degrading but still providing useful data.




Hurricane Florence from AIRS infrared data, 9/12/18
(from the AIRS Science Team)

# CERES

- Flight Model 3 (FM-3) – Excellent health
  - Voltages, currents, temperatures all look good.
  - All channels are fully operational.
  - FM-3 is fully capable of operating in either cross-track or rotating-azimuth-plane mode.
- Flight Model 4 (FM-4) – Good health
  - Voltages, currents, temperatures all look good.
  - Two of three channels remain operational (the shortwave channel failed on 3/30/2005).

Aqua CERES instruments prior to launch

(courtesy of TRW)

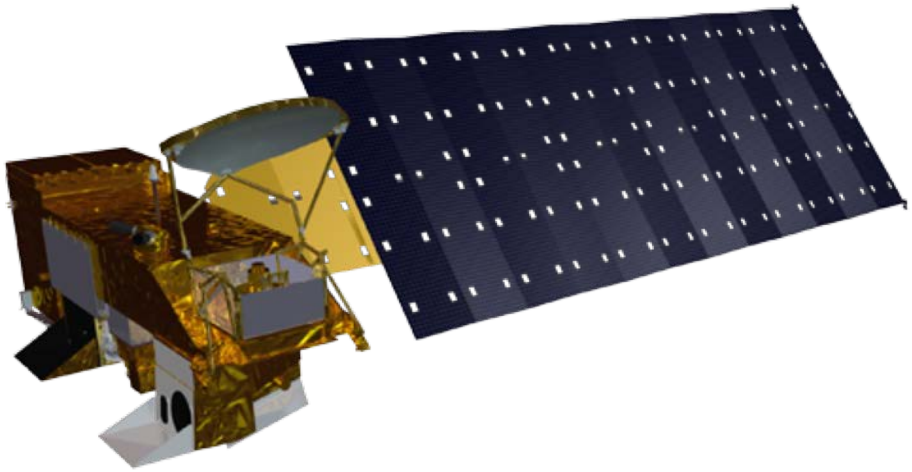
# MODIS

- Excellent health
- All components remain on primary hardware.
- Voltages, currents, temperatures all look good.
- No disturbing trends are seen in the engineering data.
- Three of four 10 W lamps used for calibration have failed.

Fires in Utah, 9/19/2018, as imaged by the Aqua MODIS
(from earthobservatory.nasa.gov)

# Status of the Aqua Spacecraft Bus, Solar Array, and Data Capture

- Overall status – Excellent
- All components remain on primary hardware.
- 117 of the 132 strings of solar cells continue to operate.
- The Solar Array could likely operate at least until early 2028.
- So far in 2018 there have been three days with data losses.
  - 3/9/18 (less than 1 minute).
  - 4/11/18 (less than 2 minutes).
  - 6/28/18 (less than 1.5 hours).



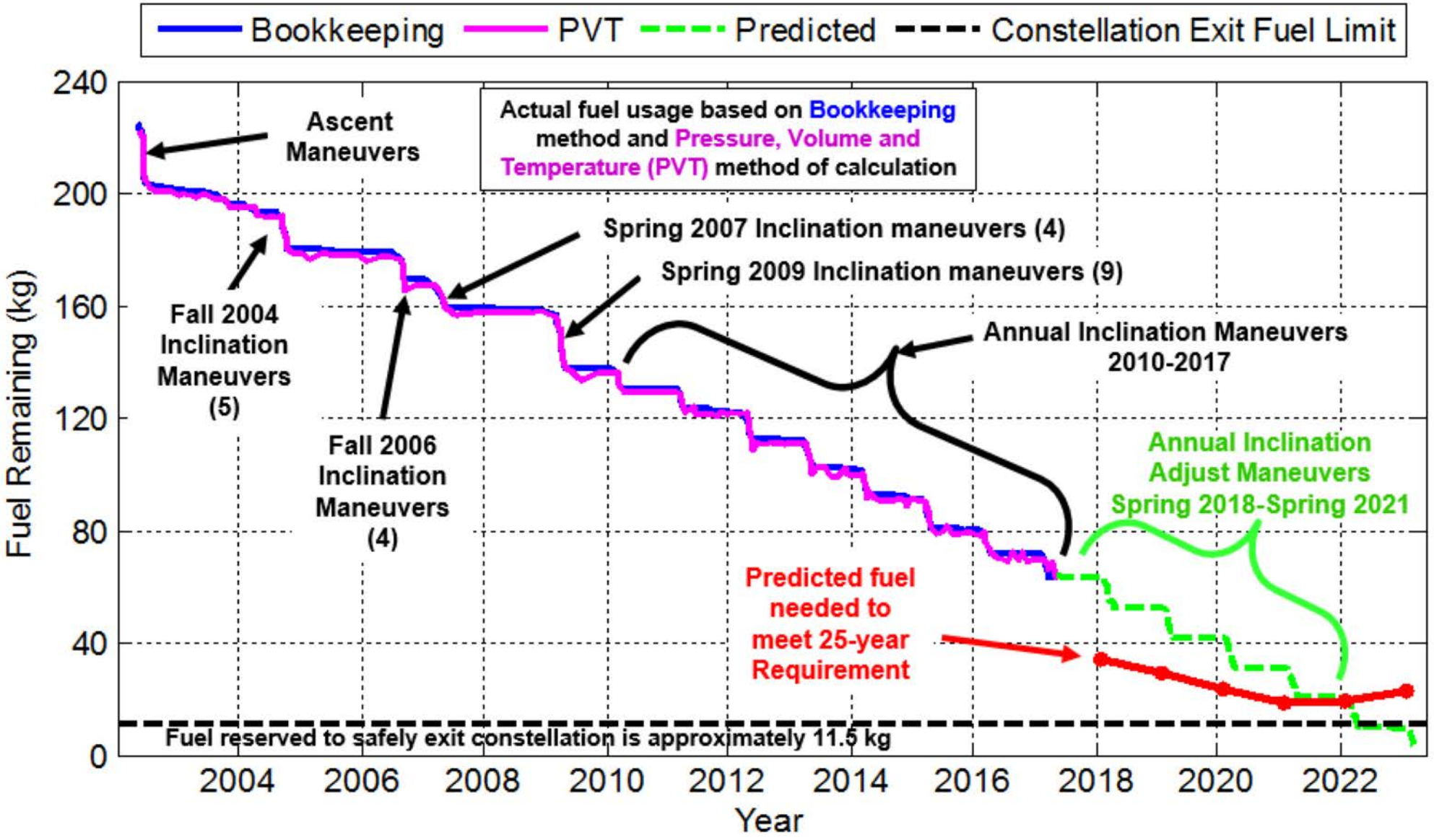
(Aqua visualization by Marit Jentoft-Nilsen)

# Aqua Battery

- 24-cell, nickel-hydrogen ($NiH_2$) battery manufactured by Eagle Picher.
- All 24 cells remain fully operational.
- Typical depth of discharge is now 12-13% (16% earlier).
- Eagle Picher's analyses with similar batteries suggest a battery life of 152,000 cycles.
- 152,000 cycles (orbits) will come in December 2030.
- CONCLUDE: The Aqua battery is projected to be capable of lasting until December 2030.

$$152{,}000 \text{ orbits} \times \frac{98.8 \text{ minutes}}{1 \text{ orbit}} \times \frac{1 \text{ hour}}{60 \text{ minutes}} \times \frac{1 \text{ day}}{24 \text{ hours}} \times \frac{1 \text{ year}}{365.25 \text{ days}} = 28.6 \text{ years}$$

# Aqua Spacecraft Fuel Levels Over Time

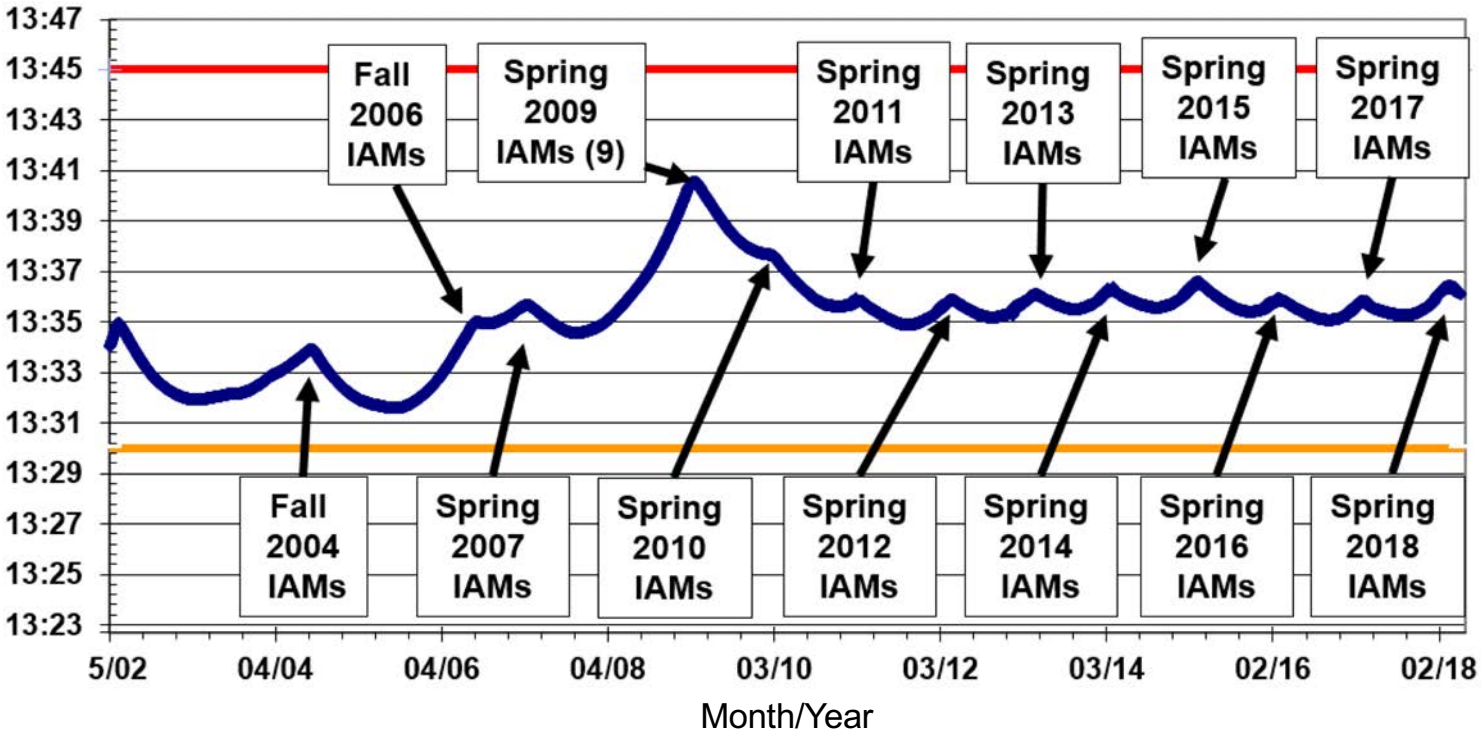



(from the EOS Flight Dynamics Team, Earth Science Mission Operations [ESMO])

# Possible Means of Extending the Aqua Mission

- Reduce the frequency of the maneuvers.
- Do the maneuvers using reaction wheels rather than thrusters.
- Exit the A-Train constellation by lowering 4 km rather than the originally planned 19 km.
- Robotically refuel the fuel tank.

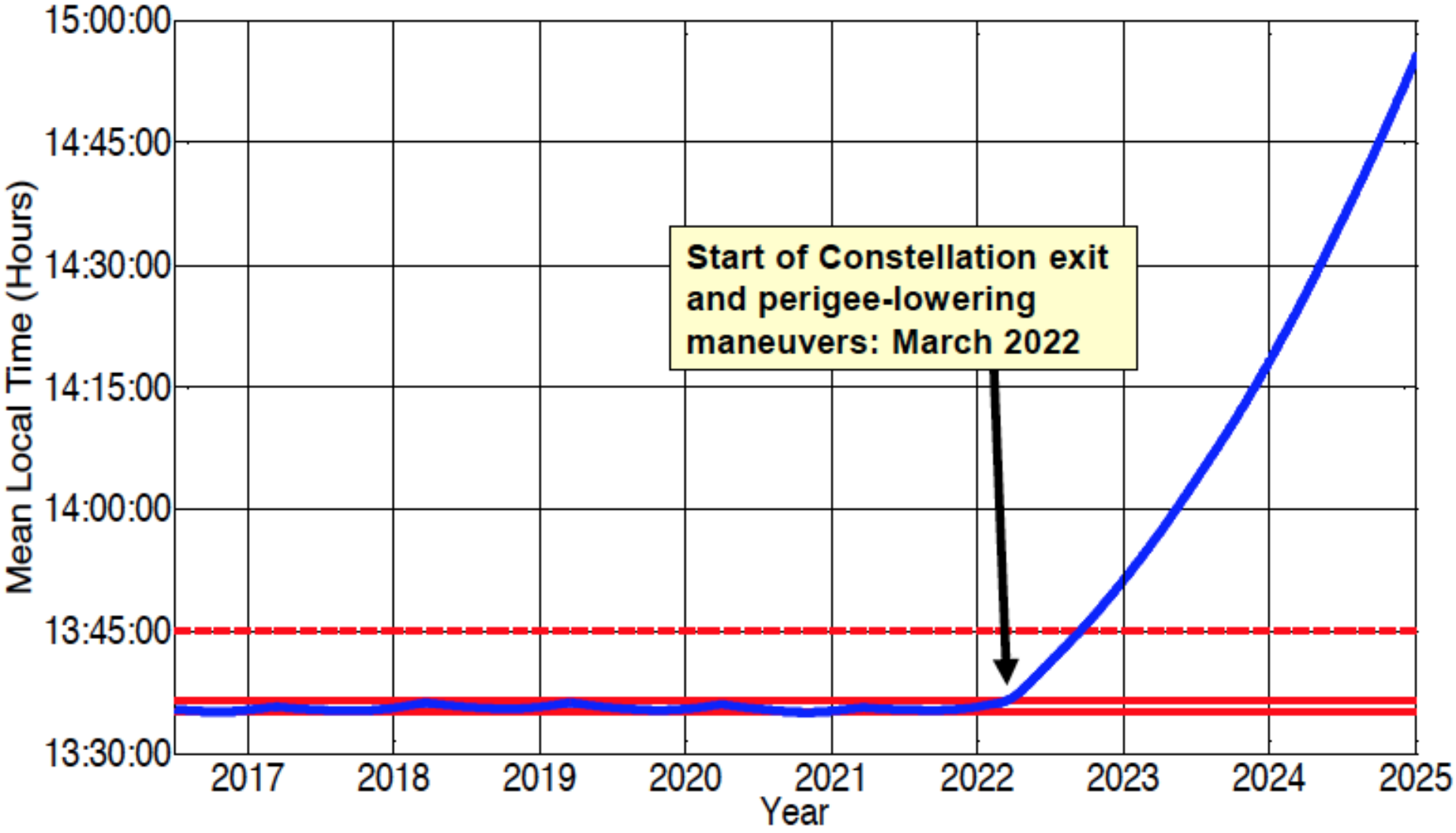
Time series of Aqua Mean Local Time (hour:minute) at the northward equatorial crossing




IAM = Inclination Adjust Maneuver

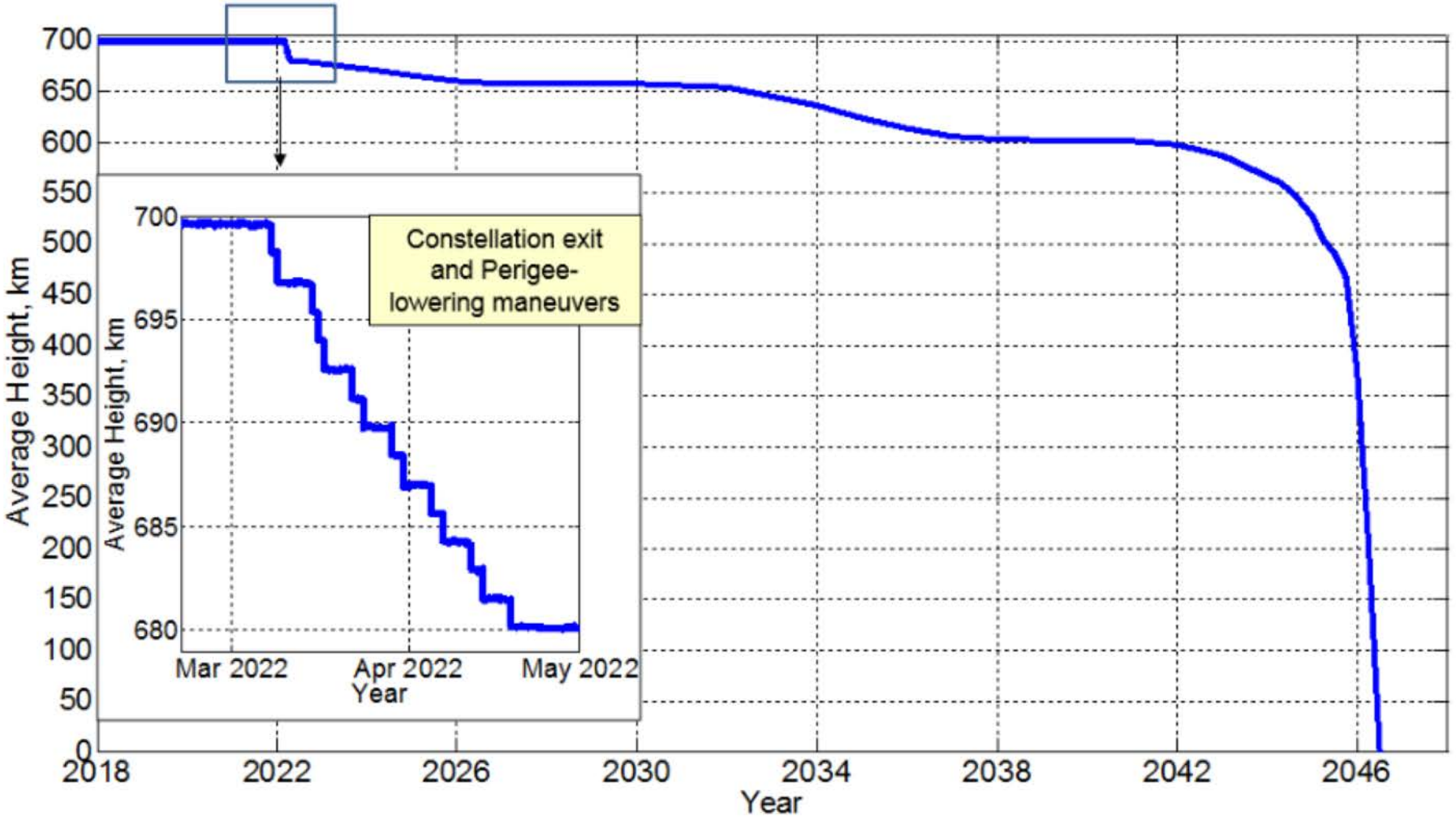
(plot extracted from an ESMO plot)

# Predicted Mean Local Time If Aqua Exits the A-Train in March 2022




(abbreviated version of an ESMO plot)

# Predicted Altitude Changes If Aqua Exits the A-Train in March 2022

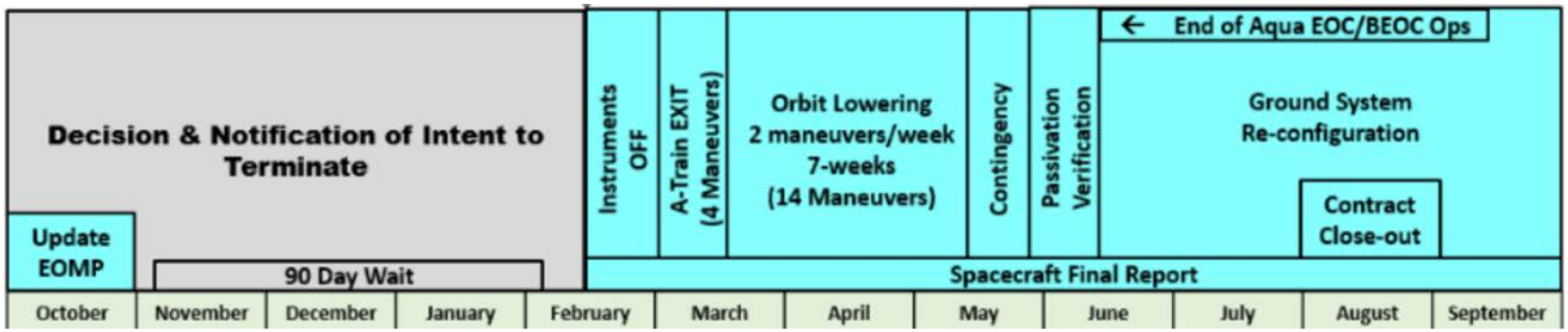



(from the EOS Flight Dynamics Team/ESMO)

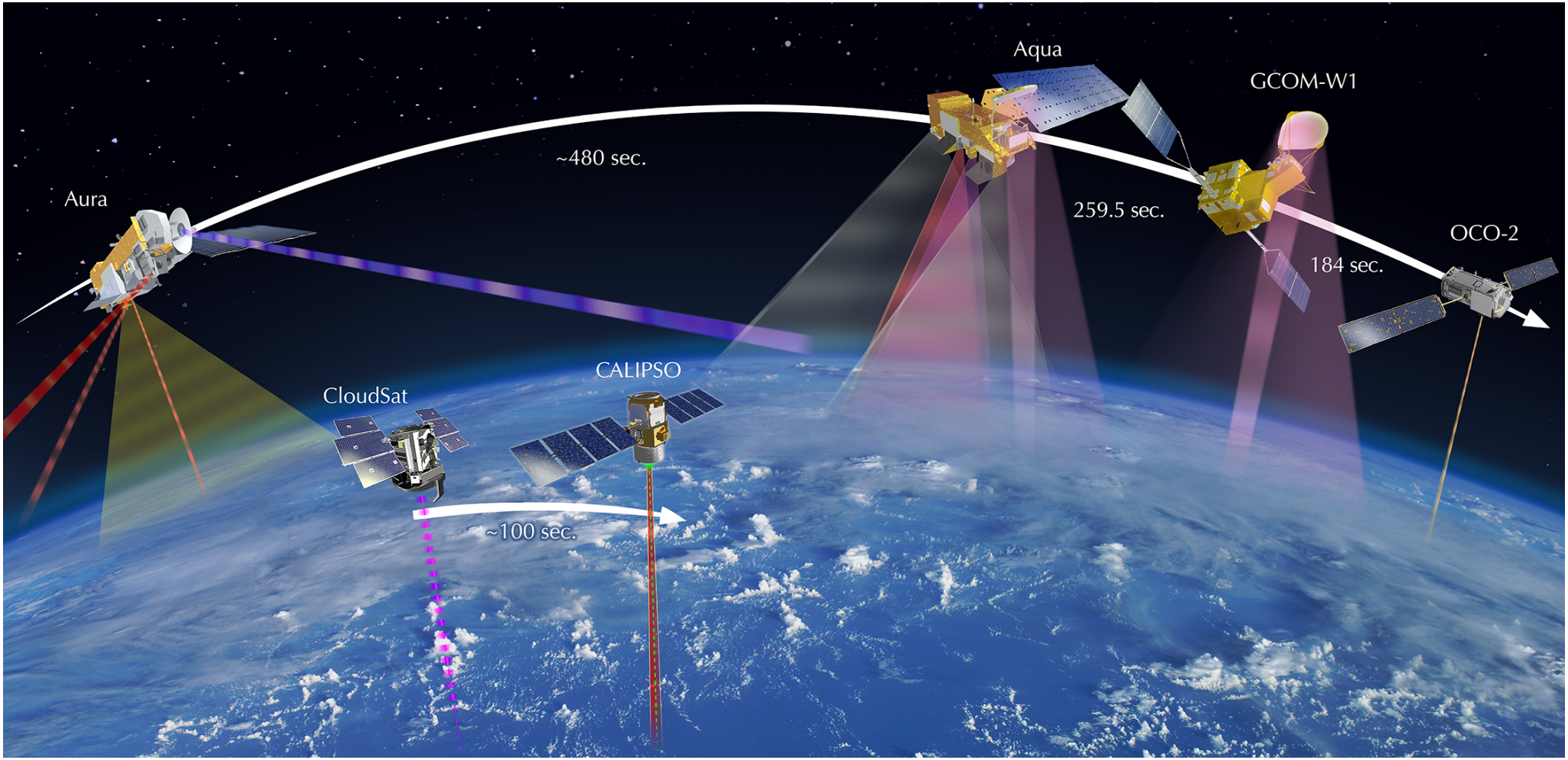
# Additional Items

- Aqua Senior Review
  - 2017 Senior Review cycle was successfully completed with a 1/16/2018 letter to Dr. Michael Freilich/NASA Headquarters, responding to all remaining questions.
  - The result is an extension of the Aqua funding through 2020 and conditional further extension through 2023.
  - The next Senior Review is scheduled for 2020.
- Algorithm maintenance activities
  - Proposals were included in the 2017 Senior Review (first time for this).
  - Administering of the funds is now done through the Aqua project rather than NASA HQ.
- Aqua Phase F Close-Out Plan
  - Presents plans for executing a close-out of the mission.
  - Was delivered to NASA Headquarters on March 28, 2018.
- New Aqua Program Scientist: Gail Skofronick-Jackson.

Decommissioning Timeline from the Aqua Phase F Plan



# A-Train (and C-Train)




(from Steve Platnick and ESMO)

- A-Train changes in 2018
  - CloudSat exited on 2/22/2018.
  - CALIPSO exited on 9/13/2018.

Acronyms
CALIPSO = Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observations
GCOM-W1 = Global Change Observation Mission – Water 1 (JAXA)
OCO-2 = Orbiting Carbon Observatory 2

# Concluding Summary

- Over 10 years beyond its 6-year design life, the Aqua mission continues to collect valuable data for science and for practical applications.
  - Spacecraft health: Excellent.
  - AIRS, MODIS, CERES FM-3 health: Excellent.
  - CERES FM-4 health: Good.
  - AMSU health: Fair.
- The solar array and battery both appear likely to outlast the fuel.
- Fuel limitations will likely lead to Aqua's exiting the A-Train in early 2022.
- After exiting the A-Train, Aqua could continue to collect valuable science data, at a lower altitude and later equatorial crossing times, until 2026.